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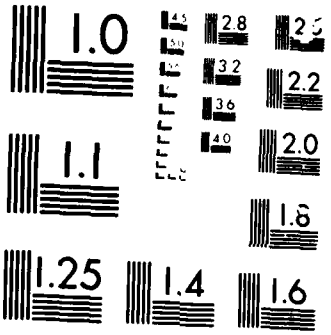
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Compact Disk Read Only Memory (CD ROM) is one of a group of optical disk products that offers great information storage potential. CD ROM Technology uses a laser to burn (record) pits in the light sensitive surface of an optical or plastic coated disk. The typical 4.75 inch CD ROM disk offers enough storage capability to hold the contents of 1,200 standard 5.25 inch floppy disks.

This report describes the current state-of-the-art and typical steps in preparing the CD ROM database, including data preparation (data indexing and reformatting), disk premastery, disk mastery, and mass replication. The strengths of CD ROM technology include high data storage density, relatively low costs for widely distributed databases, relatively high random access speeds, and disk durability and integration in the normal office environment. Limitations include the current high costs of premastering and mastering disks, and the lack of standardization among CD ROM producers. CD ROM is not an acceptable storage alternative for databases that are highly volatile, however an erasable optical disk is

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AN ASSESSMENT OF CD ROM TECHNOLOGY

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Compact Disk Read Only Memory (CD ROM) is one of a group of optical disk products that offers great information storage potential. CD ROM technology uses a laser to burn (record) pits in the light sensitive surface of an optical or plastic coated disk.

The typical CD ROM disk measures 4.75 inches in diameter and offers enough storage capabilities to hold:

- the text of 150,000 printed pages (enough to fill 250 large books)
- sharp images of 15,000 pages of business documents (enough to fill 2 tall filing cabinets)
- the contents of 1,200 standard 5.25 inch floppy disks

Any piece of the vast array of information stored on a CD ROM disk can be located within a few seconds using a database management or full-text searching system. The precompiled indexes to support this type of searching can be stored on the CD ROM disk along with the data itself. However, as its name implies, CD ROM is a read only technology. Data on a CD ROM disk cannot be erased or changed.

CD ROM, like other optical technologies, has its roots in the consumer electronics industry. During the late 1960's and early 1970's television manufacturers around the world developed read only home videodisk systems. The first viable optical videodisks were introduced by N. V. Phillips, a Dutch electronics company, in 1978. More money has been invested since then, resulting in better equipment and more facilities for producing disks, and a steady growth in the production of disks. In the early 1980's, CD ROM was developed as a medium for distributing large quantities of digital data. After the personal computer market had begun to stabilize in 1984, several brands of CD ROM drives were unveiled as prototypes. In 1985, the first commercial CD ROM drives and subsystems were released along with the first wave of CD ROM databases.

Disk Structure

As mentioned earlier, the typical CD ROM disk is approximately 4.75 inches in diameter. It is 1.2 millimeters thick and has a hole 15 millimeters across in the center. Information is represented by a spiral of small pits molded into one surface of the disk which is coated with both a reflective metal layer and a protective lacquer. The spirals of pits are 1.6 millimeters apart, giving CD ROM a storage density equivalent to 16,000 tracks per inch. This is much higher than that associated with the floppy disk (96 tracks per inch) or the Winchester disk (several hundred tracks per inch).

The electronic, mechanical, optical, and chemical products and processes used in the manufacture of the CD ROM disk and the CD ROM system have a high degree of reliability. With the exception of the photo-sensitive materials used to "burn" in the pits, all materials and processes used have been around for 20 years or longer. The disk is enclosed in glass or hard plastic to prevent damage from exposure of the oxides to the air. Based on laboratory tests the life expectancy for a CD ROM disk has been estimated to be at least 10 years.

Optics/Reading the Pits

The CD ROM disk is read via a CD ROM drive. A gallium arsenide laser beam is focused on a spiral track of pits, and the amount of light reflected back into the objective lens of the disk unit is measured and converted to digital data useable by a computer.

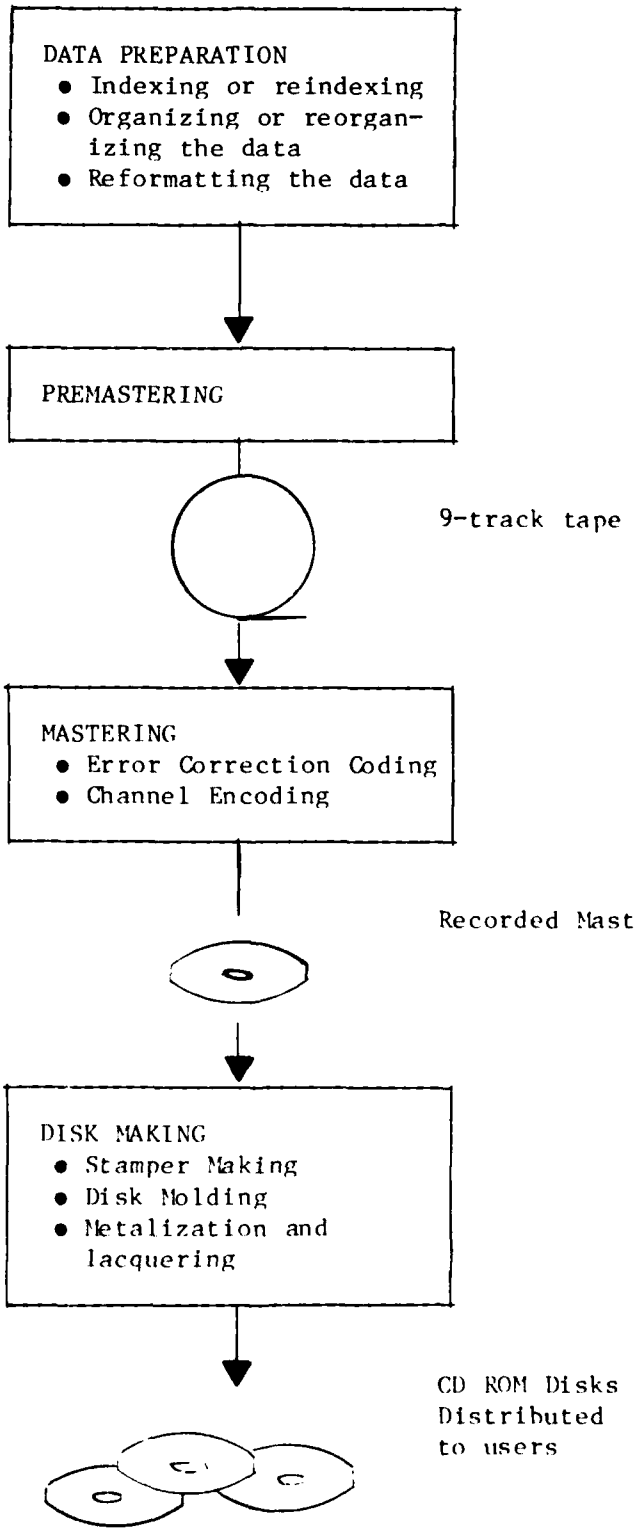
Compared to magnetic disk reading, with CD ROM the physical front of the objective lens can be over 2,000 times further from the surface of the disk. This makes "crashes" with CD ROM disks almost impossible.

Preparing the CD ROM Disk

Table 1 outlines the steps in preparing a CD ROM disk. To prepare a database for CD ROM recording, it must be reformatted to conform with the file

TABLE 1.

PREPARING THE CD ROM DATABASE



structure expected by the user's computer hardware, operating system and usage patterns.

In most cases, before reformatting, a subject database will need to be reorganized and reindexed to facilitate access by the user. During data formatting, each file and piece of information within the file is identified by name, size, and location in a way that will be recognized by a CD ROM drive. The data to be placed on the CD ROM disk, like any other normal database software, undergoes manipulation including merging, ordering, content checking and editing.

The database is indexed, creating a list of the locations where the data can be found on the CD ROM disk. The index is ultimately stored on the CD ROM disk along with the database to facilitate rapid search and retrieval. The amount of space required by the index is determined by the size of the database and the method of indexing (e.g. for limited keyword indexes only a small portion of the disk would be required, while for a complete inverted index the space required for the index might exceed the space of the database being indexed).

Other considerations during the data preparation phase include data compression, disk geography creation, and data encryption. The data is normally compressed (by eliminating empty and repetitive areas) to save space on the disk and to optimize the speed of an application. Data compression reduces the distances between items of information on the disk, and therefore, the time required to traverse those distances. Disk geography refers to the way of arranging data on a disk. Typically, files can be contiguous or sequential (written in a single block on the CD ROM disk); mapped (using an array to specify data location); or interleaved. Finally, data encryption may be used to scramble the actual data written on the disk, rendering it unintelligible without special software. Data encryption is generally used if additional database security is required.

Once the CD ROM database has been set up it needs to be tested for functionality, access speed, and reliability. Proper testing will reveal any errors in set up and will point out errors in content that may have been missed earlier. Three types of testing are generally available:

- glass master testing - using magnetic simulation of the CD ROM media
- high speed testing - using the hard disk to test accuracy of the index/ retrieval software
- CD ROM simulation - making a hard disk operate like a CD ROM to check application access speed

CD ROM premastering, accomplished by the database publisher or service bureau, usually results in reels of 1,600 bit per inch 9-track computer tape. These tapes are read into an error correction encoder, a process to ensure that the data will be retrievable despite any disk defects. Binary channel codes are used to store bits on a physical medium. Based on the values of the original data they determine the positions of beginnings and endings of the pits, and spaces written by the recording laser.

The final product is a 4.75 inch master CD ROM disk. This master disk is then used to create a stamper disk from which user copies will be mass replicated.

The user inserts his disk in the CD ROM drive of his computer system for reading. A clamping mechanism specially designed for the CD ROM disk holds and centers the disk in the drive. This mechanism cannot do a perfect job, however, an electromechanical device, the servo system, automatically corrects the focusing and tracing as the decoder recovers the formatted data.

CD ROM Advantages and Limitations

Like most emerging technologies, CD ROM is only beginning to find a niche in the business marketplace. It will probably take several years for CD ROM to gain

widespread acceptance. When evaluating whether to pursue CD ROM technology, businesses should understand the strengths as well as the limitations inherent in CD ROM technology.

The strengths of CD ROM technology are discussed below:

1. With CD ROM, users can store large permanent or semi-permanent data files that represent almost any form of text, video frames, engineering drawings, graphs, maps, microfiche images, and digital computer data.

2. CD ROM disks have a much higher data density than other storage media. As mentioned earlier, the typical CD ROM disk gives a storage density equivalent to 16,000 tracks of information per inch, while the typical floppy disk and Winchester disk give storage densities of 96 and 200 tracks per inch respectively.

3. The high data density of CD ROM equates to savings in physical space. A 4.75 inch CD ROM disk stores the equivalent of 2 tall filing cabinets, 1,200 floppy disks or 250 large books.

4. A basic CD ROM system can be set up with a relatively low cost to the user. A small CD ROM system with a personal computer, CD ROM drive, controller, and laser printer and basic software markets for $40,000 - $60,000. Blank CD ROM disks can cost less than $20 per disk, and if the user chooses to purchase widely distributed CD ROM databases with indexes and retrieval software embedded into the disk, he typically pays $200 - $250 per disk.

5. CD ROM facilitates random access to data with relatively high access times. Typical rates include average total access times of .5 - 1.3 seconds, average rotational latency times of 70 - 150 milliseconds, and data transfer rates if 150 - 176 kilobytes per second.

6. The CD ROM disk is durable. It is protected by a glass/plastic casing and withstands frequent handling and abuse. While the technology is still too

new to prove the life expectancy of a disk, laboratory tests suggest that a disk has a life expectancy of at least 10 years.

7. CD ROM can easily be integrated into the normal office environment. Prototype CD ROM systems are currently being used with all sizes and types of computers, printers and other equipment such as optical scanners, plotters, and magnetic storage devices.

8. CD ROM disks and drives operate within the normal office environment at temperatures from 50 to 100 degrees Fahrenheit.

9. CD ROM disks are removable, providing users with flexibility in off-line storage and selection of data for use in on-line operations, and the ability to physically ship data to other locations.

The limitations of CD ROM technology are associated with bringing a relatively new technology to the business marketplace, and selecting and developing appropriate applications. A summary of the limitations and management concerns in using CD ROM disks is provided below:

1. Data on the CD ROM disk cannot be erased or changed. Data files that change in any manner would not be good candidates for CD ROM. The fact that CD ROM disks cannot be erased, however can be viewed as an advantage when considering archival or permanent data as CD ROM assures that this type of data cannot be changed.

2. The premastering process can be very costly to users. This is a major limitation when only a few copies of a disk are required from the mastering process. However, several companies have recently announced new mastering processes which may reduce the current high cost.

3. The mastering process places constraints on the control of data and the time period for data conversion, and the master disk creation. In addition, the cost of mastering can be very expensive. The user must carefully plan and

analyze the methods to be used by the organization(s) that will be performing the premastering and mastering tasks. This constraint, along with the fact that CD ROM disks are non-erasable, has resulted in slow acceptance of CD ROM technology within the computer industry.

4. CD ROM lacks standard formats for digital data to be used as input directly to existing database management systems or for storing data files to be used as input for existing or new application computer programs that require data in normal computer codes.

5. The majority of CD ROM systems are currently custom implementations due to the lack of standards in formatting CD ROM disks and the scarcity of computer software for system control, data selection, and sequencing.

6. Many CD ROM applications require a high density scanning process to capture documents and a high resolution video monitor to obtain adequate storage and retrieval of images.

Recommendations

Although offices within the federal government such as the Library of Congress, the National Library of Medicine, and the Defense Mapping Agency are already involved in the use of optical disk technology, the uses to date have been limited. The Defense Technical Information Center (DTIC), Office of Information Systems and Technology, is currently exploring possible applications of CD ROM and other optical technologies at DTIC.

Considering the storage and efficiency potential that optical disks, particularly CD ROM offers, this type of exploration should be continued. Optical disk technology might offer a better, more cost effective solution for storage, retrieval, and display of bibliographic database records currently stored on a mainframe computer at DTIC and accessed by more than 800 dedicated and dial-up user sites nationally.

The Defense Technical Information Center should aggressively pursue the development of a CD ROM prototype system as well as application disks for marketing to user sites.

In addition, I recommend that within the Department of Defense and the services a technical coordination focal point be established for sharing information and experiences gained through CD ROM/optical disk projects. This focal point and staff members on a small technical advisory/user committee could develop recommendations for prototype systems and how to best use the technology for supporting internal and external operations. The focal point should also establish and maintain a contact list of users and experts in the field and develop an automated database that lists vendors, equipment, and services with their specific capabilities.

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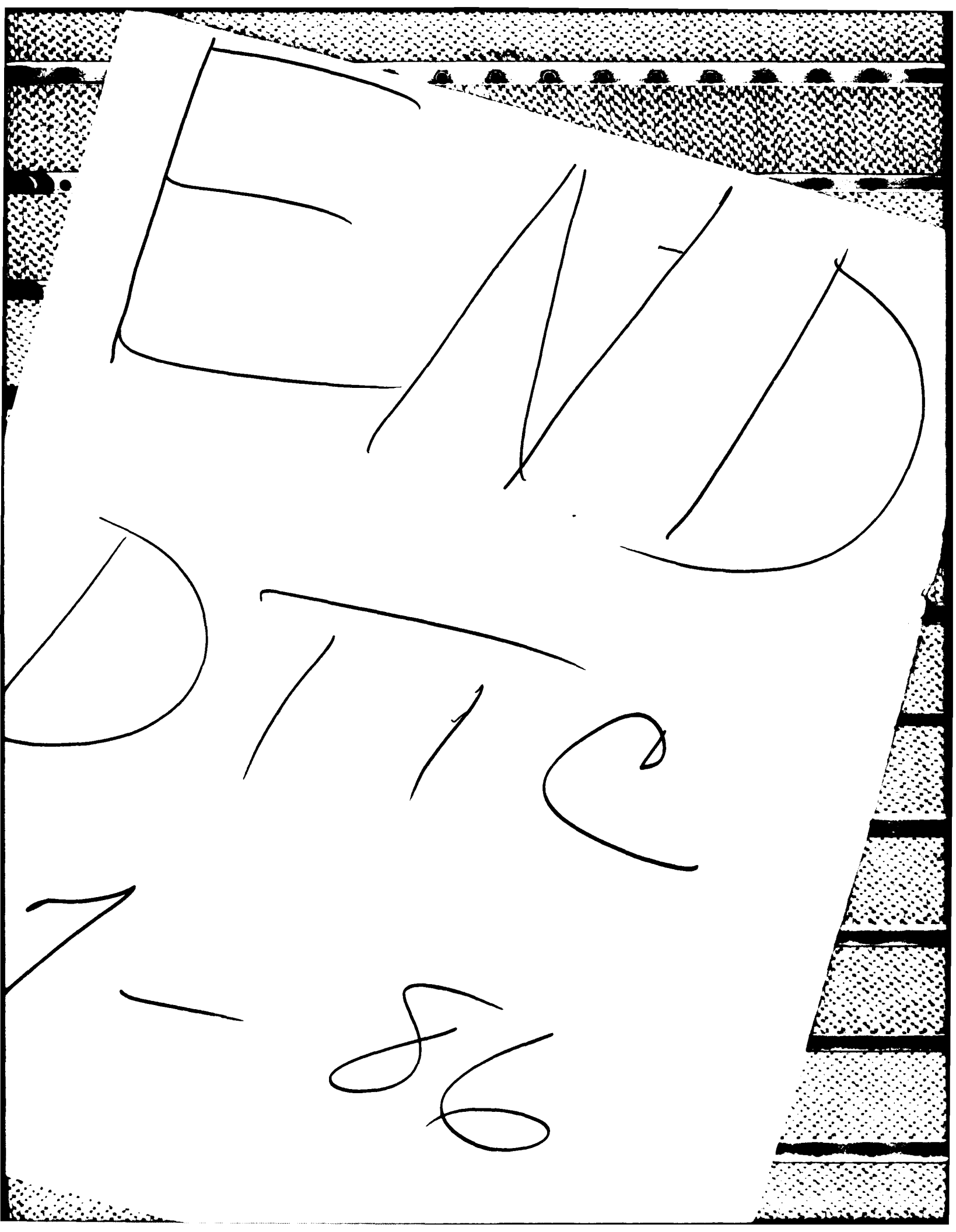
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